DOCUMENT RESUME

ED 184 859 **SE 030 512**

AUTHOR Biglan, Barbara
TITLE Urban Environmental Education Project, Curriculum Module I: Energy Generation - Sources and Consequences.
INSTITUTION Allegheny Intermediate Unit, Pittsburgh, Pa.
SPONS AGENCY Office of Education (DHEW), Washington, D.C.
PUB DATE Jul 79
NOTE 62p.: For related documents, see SE 030 511-519. Contains occasional light type.

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Class Activities; *Electricity; *Energy; Energy Conservation; Environment; Environmental Education; Fuel Consumption; *Fuels; *Natural Resources; *Science Education; Secondary Education; Urban Education
IDENTIFIERS *Energy Education

ABSTRACT

Included in this module are five activities dealing with sources and consequences of power production. The activities include: (1) review of the nature of energy; (2) options for power production; (3) energy resources and their sources; (4) energy and the future; and (5) a simulated energy conference in 1984. Also included are an overview, teacher background information, an activity preview, a pretest, and a module evaluation form. (RE)

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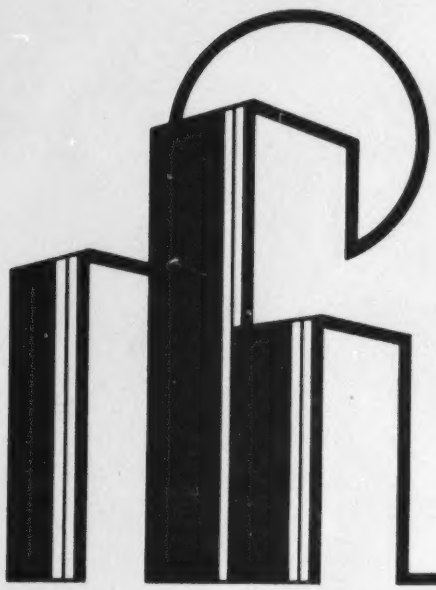

Curriculum Module I

Urban Environmental Education Project

Energy Generation: Sources and Consequences

developed by Barbara Biglan

SE 030 512

ALLEGHENY INTERMEDIATE UNIT

Instructional Support Services
Suite 1300, Two Allegheny Center
Pittsburgh, PA 15212

Dr. Harold E. Oyer, Executive Director
Dr. Therese T. Walter, Assistant Executive Director
Dr. Daniel R. Nicholes, Director of Citizenship Education

The activity which is the subject of this document was supported in whole or in part by the United States Office of Education, Department of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S.O.E. and no official endorsement by the U.S.O.E. should be inferred.

URBAN ENVIRONMENTAL EDUCATION PROJECT

Curriculum Module I

Energy Generation: Sources and Consequences

developed by

Barbara Biglan

July 1979

Catherine Cornbleth, Curriculum Series Editor
University of Pittsburgh

Energy Generation: Sources and Consequences

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Energy Generation: Sources and Consequences

OVERVIEW

Our world today is on the brink of transition from primary dependence on fossil fuels (e.g., coal, oil, natural gas) for energy generation to utilization of other energy sources. Because fossil fuel supplies are running out, and because our dependence upon these energy sources is great, careful thought must be given to other energy sources. No single energy source can insure a continuance of our present quality of life. A combination of present and future energy technology must evolve. We need to answer questions about energy generating sources today!

How will new energy generating sources contribute to already serious pollution problems?

How costly are these new sources?

How safe and efficient is the current technology?

How will new energy sources affect the quality of life in our urban environment?

How will a balance between energy supply and demand and environmental protection and jobs be obtained?

In this module, energy is considered from historical, social, and scientific perspectives. Important questions are raised, and students are expected to formulate responses based upon the information they gather. What is "energy"? Why is there a crisis? What are the new energy sources? What is the price we would pay monetarily, environmentally, and socially for these new energy sources? No one person or group has a one and only

best answer to the questions of future energy generation. But, many people have examined the available facts and their implications and have taken a position on these issues. After completing this module, students are expected to reach reasonable decisions, based on the available evidence and their own values.

Some understanding of the concept of energy is necessary if energy generation options are to be meaningfully examined. Then, "new" energy sources can be introduced and analyzed. Consideration of the benefits and drawbacks of each energy source highlights the price we must pay locally, nationally, and internationally for our high, technology-dependent standard of living. Finally, students are involved in decision-making processes that necessitate making reasoned choices. To refuse to make decisions is to invite disaster.

TEACHER BACKGROUND INFORMATION

Back in the time of cavemen, the only energy sources were the chemical energy of the human body and the radiant heat energy of the sun. As civilization progressed, people learned to use the chemical energy produced by plants and animals to do work. By burning plant matter, fire became a source of energy. Animals were used to plow fields and turn grinding wheels. Wind and water currents were used as energy sources for ships and mills.

The use of heat (fire) as an energy source increased as civilization advanced. With the invention of the steam engine, fuel (burning) energy was converted to mechanical energy. As steam engines spurred industrialization, wood shortages developed, and other energy sources were needed. In the 1700's coal was mined to provide this energy.

New ways of using coal-produced energy were found. Electricity was generated by the chemical energy of burning fuel turning wheels between the poles of a magnet. The motion (kinetic) energy passing by the magnet was changed into an electric current. More electrical power was made possible by burning more and more coal.

In the 1800's, oil wells were first drilled. Oil, as well as coal, could be used to generate electricity. Initially, the principal use of oil was for kerosene for use in lamps. With the advent of the internal combustion engine and its increasing use in the 20th century, more oil was converted to gasoline to meet our growing demand for energy.

The present rate of consumption of oil in the United States is staggering. We are on the brink of a true energy crisis. What will we do when the oil runs out? What will we do before that point?

At least three factors merit our attention in any consideration of present and future energy sources. One is economic. From a worldwide perspective, nonrenewable energy resources have been vastly underpriced in the United States. For example, despite rising prices, Americans still pay relatively little for gasoline. At this writing, a gallon of gasoline costs about 90 cents in the United States compared to $2.50 in Japan. What is a reasonable price to pay for energy? What are we willing to pay? What are we willing to give up?

A second factor is our energy dependence. The United States imports a large proportion of its energy resources, particularly oil, and thus is dependent on the economic and political policies of other nations. It is unlikely that the United States will become energy independent in the foreseeable future. Our interdependence with other peoples and nations cannot be ignored.

Third, to hope for the discovery of new (currently unknown) energy resources is risky but probably not completely absurd. What is a resource depends in part on current knowledge and technology. Coal, for example, was not a resource for native Americans or European settlers in the 16th century; they didn't know how to use it. As suggested in the preceding brief energy history, energy resource use has generated more use and the search for more and/or better energy resources. What are our currently known and potentially useable but technology-dependent "new" energy sources?

BACK TO COAL? Coal could still be mined from the land. However, land reclaiming for strip mining is expensive. Also, regulations on sulfur emissions (from burning lower grade coal) restrict the use of much of our coal or increase its cost (by requiring emission controls). Many new coal areas are in the far west, and the coal must be shipped great distances to be used for energy generation. When coal burns, gases and soot are produced. Some processes for turning coal into natural gas are being explored. But, coal is a fossil fuel. Just as oil is being depleted now, coal will run out eventually.

NATURAL GAS? Natural gas is formed by the same processes which form oil. And, like oil, it can be depleted. New sources are thought to be located very far under the surface of the earth. It is believed, however, that these potential natural gas resources may be unrecoverable.

NUCLEAR POWER? In the 1970's commercial use of nuclear energy began on a large scale. Many planners estimate nuclear energy will provide 15% of our electricity by 1985. Reactors are usually placed fairly close to urban areas, where the need is greatest, in order to minimize transmission costs. Nuclear wastes and accidents are two dangers to be considered.

SOLAR POWER? The environmental damage from solar collectors is minimal. However, large scale technology for the use of solar energy needs funding for further development. Presently, solar power is feasible as a "back-up" home heating unit or as a water heating system. How likely is it that solar energy can be used on a large scale by 1990? We don't know.

WIND POWER? To extract kinetic energy from the wind on a large scale might alter weather patterns. Wind vanes or wind mills may have limited, local uses in some areas, however. Large scale energy generation by the wind is still very much in the research stage.

WATER POWER? Dams, reservoirs and waterfalls have already spawned hydro-electric plants. Recent attention has been drawn to dam leakage or failure. There are also environmental concerns about altering the course of streams and rivers and changing wild life habitats.

TRASH POWER? A seemingly ideal answer to the energy crisis is to generate methane gas by burning organic waste in specially designed facilities. Placement of these facilities poses environmental questions. Technology has been developed, but further research is necessary before nationwide use could be considered. For example, the "trash" must be processed before burning. This processing would require energy. And, the heat needed to burn the trash would use some other energy source.

GEOTHERMAL POWER? The hot springs which gush forth regularly in our national parks could be harnessed to provide an energy alternative. Realists, however, point out that we are still many years away from refining the technology necessary to use geothermal energy.

ACTIVITY PREVIEW

This module consists of five activities. Each activity involves a minimum of 45 minutes of class time. Supplementary experiences also are provided, which would increase the time needed.

Activity 1. Energy -- What Is It?

The two types of energy, potential and kinetic, are explained. The concepts of energy transformation and energy loss are developed by means of examples and diagrams. Then, students formulate their own statements of the "energy crisis."

Activity 2. Energy Generation -- What Are the Options?

Using graphs and charts, students examine present energy sources (and, optionally, historical and future, potential energy sources). After identifying criteria upon which to evaluate alternative energy sources, students obtain and record information about energy sources. Fact sheets are provided for seven energy sources.

Activity 3. Energy Sources "New" and Old -- Where Do They Come From?

Using mapping skills, the students locate areas of energy resources in the United States (or worldwide) and analyze energy resources and needs as well as environmental, economic, and social impacts.

Activity 4. Energy and My Future -- Where Do I Stand?

The students review and synthesize data about energy sources, using a handout and decision-making map to assist them in making reasoned energy choices.

Activity 5. Energy Conference, 1984

This role playing experience involves exploration of various interest groups' positions and citizen concerns as well as governmental restrictions. This simulation could be modified to encompass global issues and perspectives (e.g., Energy Commission Worldwide Conference, 1984).

NOTE: A knowledge pretest for students, reprinted on the following pages, is provided in the Student Materials Packet.

Energy Generation: Sources and Consequences

MODULE I PRETEST

1. Energy is

   a. electrical power.
   b. the ability to do work.
   c. a force field.
   d. moving electrons.

2. The two types of energy are

   a. potential and kinetic.
   b. light and heat.
   c. mechanical and electrical.
   d. kinetic and electrical.

3. Energy can be changed from one type to another. During such changes, the total amount of energy

   a. decreases.
   b. increases.
   c. remains the same.
   d. can either increase or decrease.

4. All of the following are sources of energy except

   a. coal.
   b. electricity.
   c. geothermal.
   d. nuclear.

5. Of the energy sources we use now, which one do we count on most?

   a. coal
   b. gas
   c. nuclear
   d. oil

6. The relatively new energy source that is increasingly being used is

   a. geothermal.
   b. hydroelectric.
   c. nuclear.
   d. oil.

7. One hundred and fifty years ago (in the early 1800's), most homes were heated by

   a. coal.
   b. oil.
   c. wood.
   d. gas.

8. Coal is located in all of the following areas, except

   a. California.
   b. Montana.
   c. Kentucky.
   d. Ohio.

9. Two areas containing oil and gas fields are

   a. Florida and Georgia.
   b. Nevada and Oregon.
   c. Pennsylvania and West Virginia.
   d. North and South Carolina.

10. In the United States, most of the nuclear reactors are located in the

   a. northeast.
   b. southwest.
   c. southeast.
   d. northwest.

ACTIVITY 1. Energy -- What Is It?

Objectives: In this activity, students distinguish potential and kinetic energy, list two examples of energy conversions or transformations in daily life, and formulate a statement about the nature of the crisis in energy generation.

Organizing Ideas: Urban, industrial societies use large amounts of energy.

1. Energy -- the ability of matter to move other matter or to affect the motion of other matter and thereby do work
   a. kinetic and potential energy
   b. forms of energy -- light, heat, chemical, nuclear, mechanical, electrical
2. Energy Transformations -- changing of one energy form to another, involving energy loss and generation

Resources:

Asimov, Issac. How Do We Find Out About Energy? New York: Walker and Co., 1975. This book traces the historical evolution of the term, energy, and its applications in mechanical, electrical and chemical transformations. The book is suitable for students in grades 5-8.

Chambers, Bruce. Energy, New York: Academic Press, 1963.
A detailed account of energy sources is presented here, in addition to various forms of energy, possibilities for use, and limitations.

Smith, Norman F. Energy and Environment. Austin, Texas: Steck-Vaughn Co., 1974. This book addresses the development of fuel sources and their effects upon the environment in historical context. Also, some future

energy sources and their environmental impact are considered. Suitable for students in grades 5-8, this book might be used to increase the historical dimension of this activity.

Thirring, Hans. Energy for Man. New York: Harper & Row, 1962.

Energy sources, from windmills to nuclear power, are presented here, including present and future production potential.

This World of Energy. National Geographic Society, 1974.

This series of 13-14 minute sound filmstrips includes: Energy in the Earth; Using Energy (historical perspective); Fossil Fuels; Nuclear Power; and Energy for the Future.

Student Materials:

About two feet of string and a weight (for the Pendulum Experiment)

Ten books or dominoes (for the Energy Loss Demonstration)

Handouts (provided in the Student Materials Packet)

What is Energy? What Difference Does It Make? (SM 1.1, 1.2)

What Forms of Energy Are There? How Efficient Are They? (SM 1.3, 1.4, 1.5)

Suggested Procedures:

1. Parts A, B, and C are designed to be completed by students working individually with handouts SM 1.1 and 1.2. You or one of the students might read the "News Flash" and introductory statement aloud as an introduction. Then, students might share their responses to Part A, and perhaps compile a class list for future reference in later Module activities.

a. Part A, SM 1.1, might be expanded to include and compare students' energy use with that of their grandparents when they were about the same age (about 55-60 years ago), the pioneers (about 150 years ago), or the Pilgrims (about 350 years ago).

b. In Part B, Sm 1.2, the book still on the shelf (A) and the one on the floor (C) represent potential energy. The falling book (B) illustrates kinetic energy.

c. The optional pendulum demonstration, described on page 10, might be used before or after the roller coaster illustration in Part C, SM 1.2.

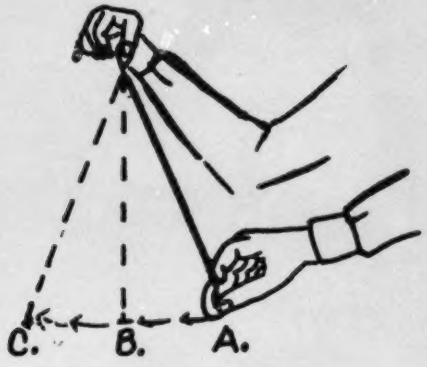
d. The potential-kinetic roller coaster in Part C, SM 1.2, illustrates continuing energy transformations. Potential energy is stored at points A, C, D, and F. Kinetic energy is on the move at points B and E. While potential energy changes to kinetic and back again (and again), energy is lost in the transformations.

2. When students complete SM 1.2, they might check their responses with you or each other, review the questions and answers as a whole group, or try the optional Pendulum Demonstration described on page 10.

3. The optional pendulum demonstration described below further illustrates kinetic and potential energy and introduces the concept, energy transformation. This experiment can be used as a teacher or student demonstration for the entire class, or it can be used by students working in pairs or small groups.

PENDULUM DEMONSTRATION

Using a piece of string approximately 20 inches or 50 cm., make a pendulum. To make the bulb or heavy end of the pendulum, either attach a weight or make a large knot or bundle at one end of the string. Hold the pendulum in position A as shown below. Let the pendulum swing freely.



a. When does the pendulum have potential energy?

b. When does it have kinetic energy?

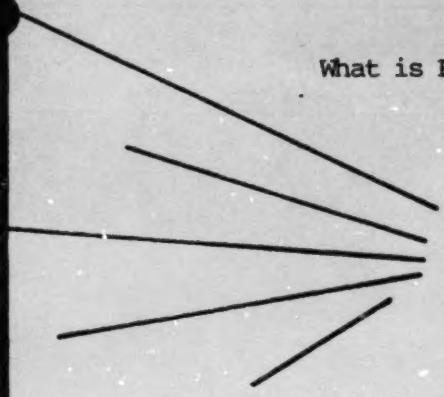
c. What did you do to start the pendulum in motion?

D. What eventually happened to the pendulum?

Friction (air) makes the pendulum stop eventually. But, a more continuous motion can be achieved by having one pendulum weight bump another pendulum weight, that bumps still another.

When you let the pendulum go, the potential energy changed to kinetic energy. When the pendulum came to the top of its swing (c), it stopped for a split second as kinetic energy changed back to potential. As it moved down again, potential changed back to kinetic. This change is called energy transformation.

What is Energy? What Difference Does It Make?



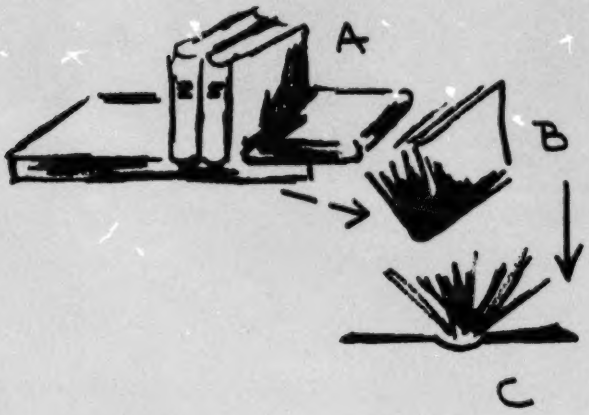
> NEWS FLASH: There is a national energy crisis! Next week the local 'citizens concerned about energy' will meet!

You have been asked to speak at the local citizens' meeting. The group wants to hear the young people's point of view on energy, since it's your future that's at stake. The following activities will help you prepare for your presentation.

A. Some scientists and engineers describe energy as the ability to do work. Work means the movement of matter from one point to another. Primitive people had only the strength of their bodies as energy. Later people tamed animals and used the animals' energy or strength. Energy also can come from the wind. Wind can move boats and turn wheels (windmills). Water can be the energy to turn wheels. Fossil fuels like coal, oil, and natural gas can be burned to heat water to make steam. Steam can be used to generate electricity. Nuclear reactors have been used to generate electricity too. List 5 ways you have used some energy this week.

1. _____
2. _____
3. _____
4. _____
5. _____

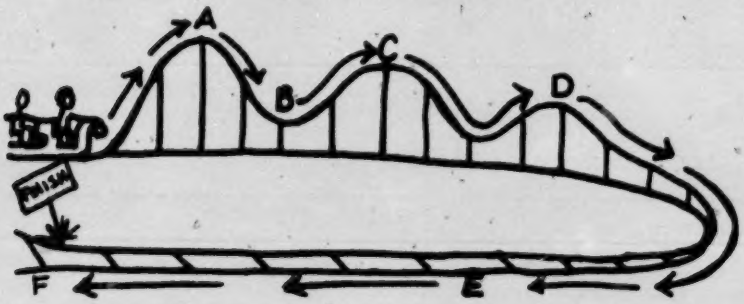
B. An English scientist, Thomas Young, invented the word "energy" in 1307. Young made the word "energy" from a Greek expression that means "work inside." There are 2 types of energy: kinetic or motion energy and potential or stored energy. Look at the following picture. What is happening?



Potential energy (A, B, or C?)_____

Kinetic energy (A, B, or C?)_____

C. Most roller coasters work on changes of energy from potential to kinetic. These changes are called energy transformations. Look at the roller coaster diagram below. Mechanical energy is needed to pull the coaster to point A. Label all points either potential or kinetic energy.



A._____ D._____

B._____ E._____

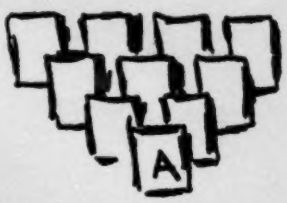
C._____ F._____

These changes from potential to kinetic energy and back again are called energy transformations. This "good news" is called the Sum of Conservation of Energy. Energy cannot be created or destroyed, only changed. ??? Then, why do we have an energy crisis if potential changes to kinetic and back again forever and ever? Wait and see.

4. Part D is a teacher or student demonstration to illustrate energy loss and costs, the "bad news" about energy. Although all matter has potential and kinetic energy, something has to start the transformation from potential to kinetic. For example, mechanical energy is necessary to pull a roller coaster up to the top of the track.

ENERGY LOSS DEMONSTRATION

a. Assemble 10 books or dominoes. Arrange them so that they stand upright as shown below.



b. Gently push book (or domino) A in the center. What happens? (The front book falls on the ones behind it, each row pushing and toppling the one behind it. In other words, the potential energy changes to kinetic and then (when all the books have fallen down) back to potential.)

c. Then what happens?
(Nothing -- unless an outside source of energy lifts the books into place again and pushes book A.)

d. Arrange the books or dominoes so that they stand upright as shown below. (This demonstration represents what occurs in a nuclear reaction.)

e. Gently push book (or domino) A as shown. What happens? (Some, but not all, of the books fall down.)

f. Not only is an outside source of energy needed to lift the books into place again and push book A to restart the reaction (energy transformation), but not all of the potential energy was used. This is the "bad news" about energy.

g. As a follow-up to this demonstration, students might consult an up-to-date science text and compare controlled (reactors) and uncontrolled (bombs) nuclear reactions or examine the "breeder" reactors that generate new fuel sources to generate more energy.

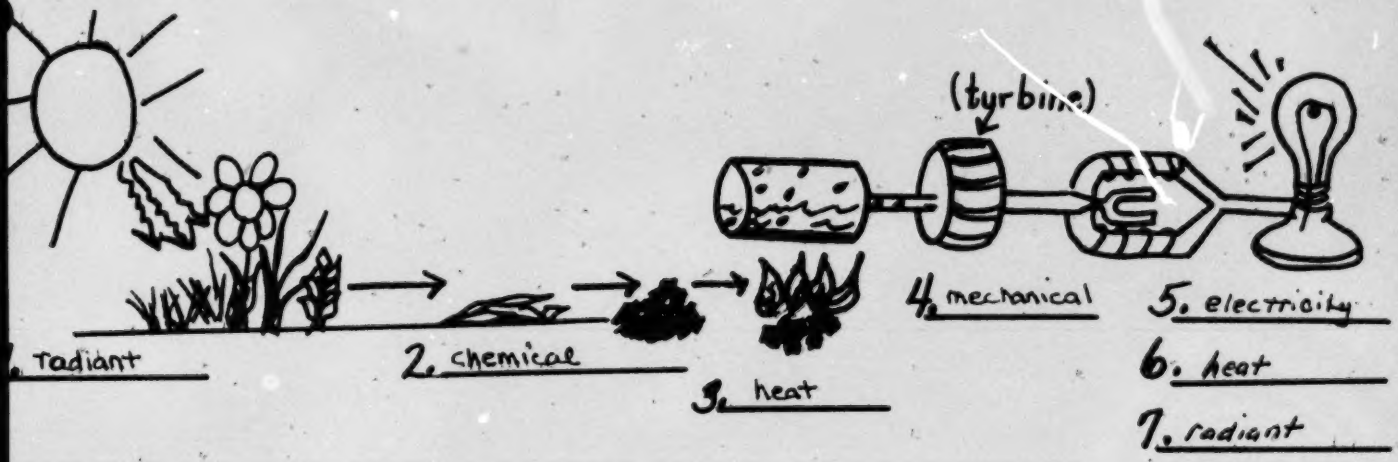
5. Parts E, F, and G are designed to be completed by students working individually with handouts SM 1.3-5. However, the handouts also might be used and completed in a small or large group format.

a. Part E, SM 1.3, further illustrates the concepts of energy transformation and energy loss, using the automobile as the major example. An optional energy transformation demonstration also might be used to show how the radiant heat from the sun can be collected and directed to provide heat energy. Use a small hand-held mirror to catch the sun coming in the classroom window. By tilting and tipping the mirror, direct the sun's rays to a small sheet of paper. After a few minutes, a hole will burn in the paper.

b. As a follow-up, students might compare different types of car engines (battery, steam, electric) with the internal combustion engine shown in the diagram in terms of form(s) of energy used, energy transformations, and energy loss. They also might begin to consider the environmental effects of using different types of automobiles and

energy. Another possible follow-up would involve tracing the historical development of transportation and energy use from walking to space flights and considering the impact on the environment and quality of life of these different forms of transportation. (The National Geographic sound filmstrips, noted under Resources, particularly Using Energy, provide historical perspective.)

c. In Part F, SM 1.4, the generation of electricity is used as an example of energy transformation and how energy resources are used up. Students might be asked to draw a picture or diagram of what they have read in the second paragraph. Or, they might use the information to label a diagram that you provide with the kinds of energy used. For example:

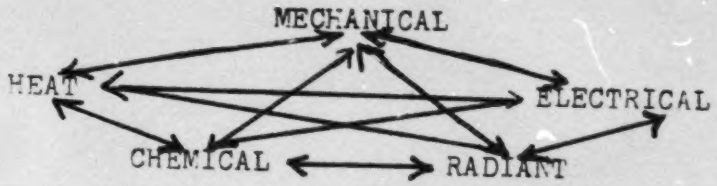


As a follow-up, students might construct a model illustrating the generation of electricity, using an energy source of their choice.

d. Part G ends Activity 1 by asking students to consider how their lives would be different (and how they would feel) if there were less electricity (energy) or no electricity available and to develop their own statement of the "Energy Crisis." Suggest that students refer to the list they compiled at the beginning of this activity, Part A, to remind them of the many ways in which they use energy. Students might share their responses in small or large group discussions. Their conclusions might be recorded for future reference (e.g., comparison with their positions at the end of the module).

What Forms of Energy Are There?

E. There are several forms of energy. One form can be changed into another, just as potential energy can be changed into kinetic energy (and back again, on and on . . .). Different forms of energy are shown in the following diagram. The lines and arrows indicate that one form of energy can be changed into another.

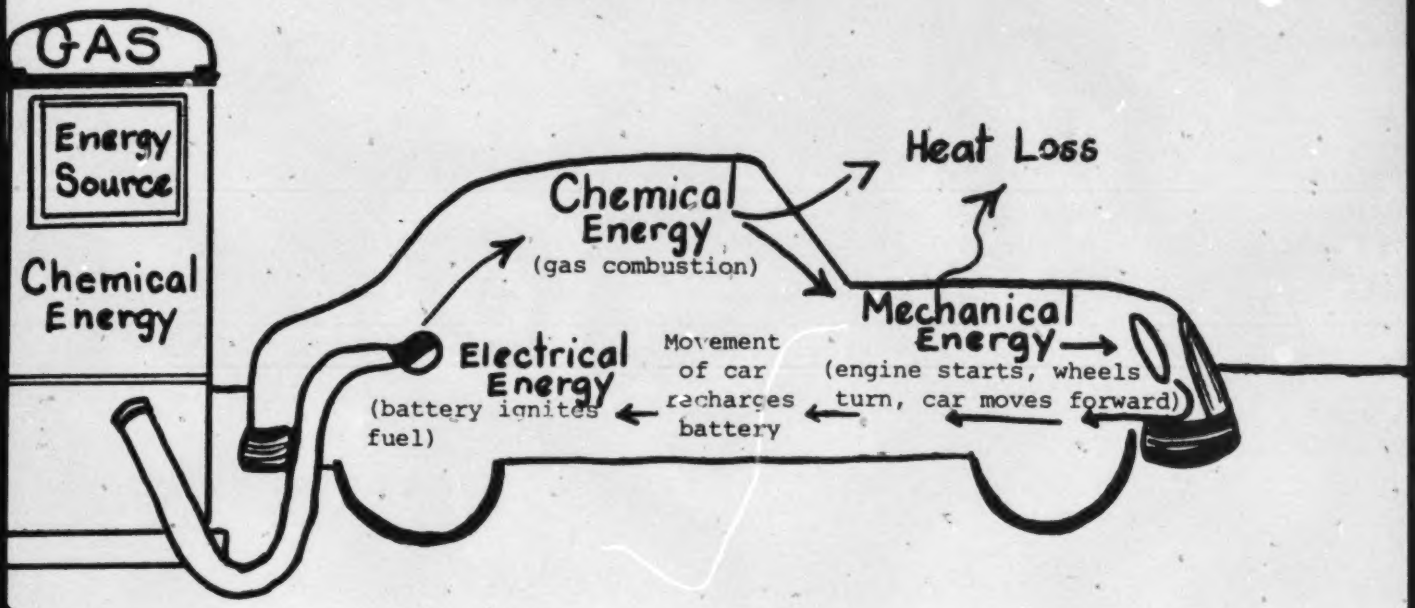


For example: (1) The chemical potential energy stored in the food you eat is released when the food is processed by your body. As the chemical energy disappears, an equal amount appears as muscular energy and body heat.

(2) When batteries are used in a flashlight, the chemical energy in the batteries is transformed into radiant and heat energy.

(3) Automobiles use mechanical, chemical, heat, and electrical energy. When a car is running, heat energy is lost. (This energy loss is another example of the "bad news" about energy.)

Now, look at the following diagram that shows how energy is used in cars. Follow the chain of energy transformations and energy losses from the energy source (gasoline) all the way around.



To keep the energy transformations going, the price paid is heat loss plus the cost of the energy source (gasoline, in this case). This is "bad news"!

F. There is more "bad news." In addition to the cost of the original energy source and heat loss, sometimes energy resources are used up. And, sometimes energy use also results in pollution. Electricity provides a good example.

Lighting just one electric light bulb is a complex process that requires several energy transformations, involves some energy loss, and uses up energy resources. Radiant energy from the sun helps plants to grow. Decayed plants eventually form coal, which provides chemical energy. When coal is burned, heat energy is created that heats water to produce steam to run turbines. The mechanical energy from the turbine passes through a magnetic field to provide the electric energy to light the bulb. And, finally, the lighted bulb produces both heat and radiant energy.

In this process, the plants and coal are used up and cannot be recovered; the steam can be changed back to water. Heat is lost when the plants grow, when the coal heats the water to produce steam, when the turbine is working, and when the light bulb is burning.

What is likely to happen as coal supplies are used up? (Coal is a non-renewable resource; it cannot be reproduced.)

G. Now, imagine that there is no more electricity. List five things that you would not be able to do if there were no more electricity.

1. _____

2. _____

3. _____

4. _____

5. _____

Think about how you would feel if you were forced to live with less electricity. What would you give up?

How would you feel if you had to live without any electricity?

Now that you have found both the "good news" and the "bad news" about energy, write a letter to Ms. Sigma, who is the leader of the Citizen's Advisory group, telling your point of view about the "Energy Crisis" and what you would say at a local citizens' meeting.

ACTIVITY 2. Energy Generation -- What Are the Options?

Objectives: In this activity, students identify aspects of their own energy consumption, identify the advantages and limitations of several new energy sources, and rank the energy sources according to selected criteria.

Organizing Ideas: Urban, industrial societies have several options from which to choose regarding the means of generating the energy they demand.

1. Energy sources
   a. running water
   b. solar
   c. wind
   d. fossil fuels (coal, natural gas, oil)
   e. geothermal
   f. nuclear
2. Criteria for evaluating the advantages and limitations of alternative means of generating energy
   a. supply
   b. technology (technological feasibility)
   c. economic costs and benefits
   d. environmental effects

Resources:

Fowler, John W. NSTA Energy - Environment Source Book. Washington, D.C.: National Science Teachers Association, 1975.
This is a technical but readable source. In addition, several current energy issues are examined, and important aspects of future energy generation are considered.

Pamphlets, available from the Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830:
Fossil Energy (coal, natural gas, oil, shale oil, coal gasification)
Solar, Geothermal and Advanced Energy Systems
Nuclear Energy

Pamphlets and speakers are often available through Project Pacesetter, 412/281-7453.

Energy and Everyday Life. National Geographic Society, 1978. This series of 11-14 minute sound filmstrips, intended for young children, includes: Sun, Wind, and Water; Energy From the Earth (fossil fuels); and Saving Energy (nuclear energy).

Student Materials:

Handouts (provided in the Student Materials Packet)

Energy Generation -- What Are the Options? (SM 2.1, 2.2, 2.3)

Fact Sheets: Oil (SM 2.4)
Coal (SM 2.5)
Nuclear (SM 2.6)
Solar (SM 2.7)
Geothermal (SM 2.8)
Moving Water (SM 2.9)
Wind (SM 2.10)

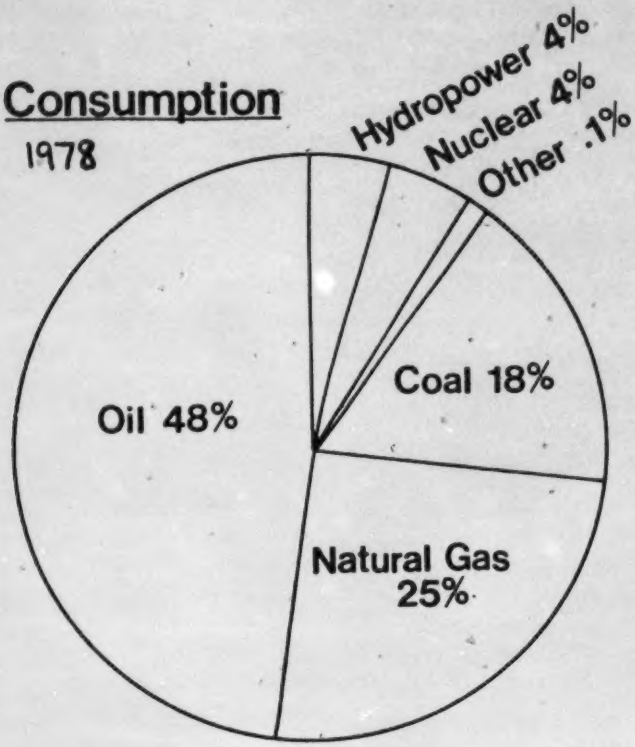
Suggested Procedures:

1. Part A is designed to be completed by students working individually with handouts, SM 2.1-2. (Electricity is not included as a primary source because all five energy sources are used to produce electricity. The last question highlights our dependence on oil imports.)
   a. This segment might be expanded by asking students to compare current energy sources with those most used in earlier periods and to offer explanations for the differences. The necessary information can be found in the NSTA Energy - Environment Source Book or Smith's Energy and Environment (see Activity 1).
   b. Students also might draw a circle graph for the year 2030, indicating (1) what they expect the distribution of primary sources of energy to be 50 years from now and (2) the reasons for their predictions.

2. Review and compare students' choice of questions from SM 2.3, using questions such as: Which questions did you select? Why is that important to you? (Why didn't you check ...?) Students might research the same or different questions for each energy source. (Using the same questions facilitates comparison, but some questions and answers might be more important for one energy source than another.)
3. Here, students "research" one or more energy sources of their own or your choosing, working individually or in small groups, using the criteria they selected or those determined by the class as a whole. Their findings might be presented orally or in writing, perhaps in chart form to facilitate later comparison of energy generation options; alternatively, a large wall chart might be compiled by students. In addition to the Fact Sheets, it would be desirable to provide library and other outside references.

Energy Generation -- What Are the Options?

A. This graph shows the five primary sources of energy used in the United States today. These sources supply Americans with most of their energy. Answer the following questions, using the information provided in the graph.



1. Which source is used the most? _____

2. Which of the sources listed is used the least? _____

3. The category of "fossil fuels" includes natural gas, oil, and coal. What per cent of the energy used in the United States comes from fossil fuels? _____

4. Why do you suppose that electricity is not included as an energy source? _____

_____

5. What sources of energy are used to heat your home?

_____

to light your home? _____

6. What source(s) of energy do you use to get to school?

_____

7. When you go to a restaurant for a hamburger and a soft drink, what energy sources are you using?

_____

_____

8. If you were the head of the government of a nation with large supplies of fossil fuels, which one would you be most likely to sell to the United States? _____

Why? _____

_____

_____

B. The demand for energy is increasing. Current practices will not satisfy future needs. Before we decide how to change our use of different energy sources, we need to find out more about the choices open to us.

We need some specific information in order to decide how best to increase our future energy generation. Some criteria, in the form of questions, are listed below; these are the things that we need to know. Check the five questions that you believe are most important.

Supply

___ How much of the energy source is available for use?

___ How dependable is the supply?

___ How soon will available supplies run out?

Technology

___ How practical is it to use the energy source?

___ What are the health and safety risks?

Economics

___ How expensive is the energy source? (In other words, how much does it cost to produce and use?)

___ What are the storage and transportation costs?

Environment

___ How would use of the energy source affect air, water, and soil pollution?

___ How would wildlife habitats be affected?

Other

___ How would United States' relationships with other nations be affected if more of the energy source were used?

___ _____

___ _____

FACT SHEET: OIL

The United States is estimated to have only 8% of the world's known supplies of oil. The Middle East, on the other hand, possesses 62%, most of which is in Saudi Arabia. South America has several oil producing areas as does Mexico and the Soviet Union.

These oil producing areas were formed hundreds of millions of years ago from the decay of plant life. The decayed materials were chemically changed through the action of heat and the pressure of the rock layers of the earth.

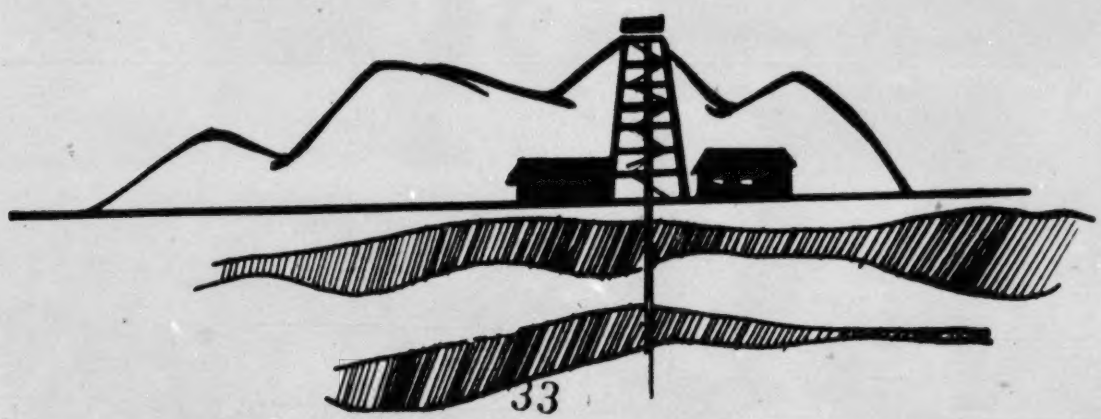
There are no physical or chemical characteristics of oil that make it possible to pinpoint underground deposits from the surface of the earth. The various methods of looking for oil can only, at best, give an indication of the chance of finding oil at any one spot.

The actual drilling for oil is a complex and expensive process requiring hundreds of thousands of dollars. The new technique of off-shore drilling is also very expensive. First a platform must be built. Then the traditional oil well is built on the platform. The oil well has a large drill which is put down into the rocks under water. This drill digs through the rock layers until oil is found. When the oil is found, the well is capped until the oil can be pumped to the surface.

There are great financial risks involved in oil drilling. In a 6 month period, 16,000 wells were drilled in the U.S. Four thousand (4,000) of these turned out to be dry wells. Even after the oil is located, it must be "refined" before it is useful to us. The refineries cost millions of dollars to build and operate. Yet, without these refineries we could not use the oil. The refinery turns crude oil into gasoline, kerosene, jet fuel, heating oil, and many other products.

While the oil is miles beneath the surface of the earth, it causes no pollution. Unfortunately, after the crude oil is found in the remote parts of the world, it must be transported to the refinery. If an oil tanker ship is damaged at sea, serious water pollution threatens sea life and birds. Often the smoke from refinery fires pollutes the air and threatens lives.

Our present life style depends on an abundance of oil. What will our future hold?



FACT SHEET: COAL

Coal deposits are found in many parts of the world. The United States has large coal deposits. Some estimates of our total coal resources go as high as three trillion tons. Not all of this supply is recoverable, however. The more meaningful estimates deal with recoverable reserves (the coal that can be mined without major difficulty).

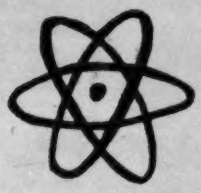
Given today's prices, current technology, and existing environmental concerns, the amount of economically recoverable coal reserves is estimated to be in the 250-300 billion ton range. These reserves could last at least 300 years. Coal reserves account for 90 percent of this country's total fossil energy reserves. By way of comparison, natural gas accounts for four percent, and oil accounts for about three percent.

There are two basic types of coal mining: surface and deep (underground) mining. Each method produces half of the coal from the United States.

Surface mining is more economical than deep mining. But, the cost of transporting the coal from the surface mines in the western United States is very high. Also, the western coal is sub-bituminous; it does not produce heat as efficiently as the coal found in the eastern United States. Surface mining also has encountered opposition from environmentalists.

Deep mining, which is the principal coal mining method used in the eastern part of the country, also has problems -- both environmental and technological. Most of the high Btu coal in the east is also high in sulfur content. The Clean Air Act of 1970 imposes rigid sulfur emission standards. Stack-gas scrubbing, a technique for reducing sulfur emissions, is costly and creates its own environmental problems.

While coal is abundant in the United States, compared to natural gas and oil, it is not without problems as an energy source. What will our future hold?



FACT SHEET: NUCLEAR

Nuclear energy is used to generate electricity. Like most methods of generating electircity, the fuel is burned to produce heat, the heat makes steam, and the steam drives a turbine to make electricity. The difference between nuclear power plants and conventional power plants is the fuel. Conventional plants burn fossil fuels -- natural gas, oil, or coal. The nuclear fuel most commonly used today is uranium-235. In a nuclear reactor, the fuel atoms fission, that is, they split apart, and this process releases tremendous quantities of heat to make electiricty.

Use of our uranium supplies will help reduce the cost of electricity. In 1975, nuclear plants produced electricity for a total cost that was 63% less than that for oil plants and 30% less than that for coal plants; this saved consumers over $2 billion on their utility bills. If all costs are included (such as construction, operation, maintenance, and disposal of wastes) nuclear plants still are more economical than fossil fuel plants.

The technology necessary to build nuclear plants is well established. As of April 1976, 59 power reactors were operating in this country and were supplying more than 9% of our electricity. Nuclear power is growing; it now supplies twice as much electricity as it did 2 years ago, and its contribution is expected to increase.

In recent years, concern about the safety of nuclear power plants has grown, even though the plants have compiled a good safety record. Some opponents of nuclear energy are demanding a complete halt to new nuclear plant construction and a phasing out of units already in operation because nuclear could be dangerous under some circumstances.

Nuclear power is recognized as a clean source of energy. Chemical pollutants are not released into the atmosphere. Nuclear plants are designed to contain practically all radioactive material in a closed system. A major environmental concern is "thermal pollution." Nuclear plants use large amounts of water to cool the reactors and then return the water to its source several degrees warmer. That has caused problems in the past. However, cooling towers can be built to cool the water before it is returned.

Disposal of nuclear waste also is a serious concern. Still, most of the wastes are not highly radioactive. They are disposed of in commercial burial grounds. The small amount of waste that is highly radioactive is disposed of in ways that are reported to involve little risk to the public or to the environment.

Another concern about nuclear power is that facilities might be sabotaged or that nuclear materials might be stolen and released to the environment or used to construct weapons. Today very strict measures are in effect to safeguard nuclear materials, and safeguard systems are continually being upgraded. Compared to coal, natural gas, and oil, nuclear energy is more abundant and economical but, potentially, more risky. What will our future hold?

FACT SHEET: SOLAR

The sun is free. It shines everywhere. It pollutes nothing. The sun is the source of almost all of the energy used on the earth. The sun's powerful rays, contained in plant and animal matter, can be tapped in fossil fuels such as oil, natural gas, and coal.

Or, the energy from the sun can be used more directly to provide heat or generate electricity. Solar heating uses very basic technology -- as simple as water warmed by flowing over a sun-heated roof being used to heat a house.

Generating electricity from solar energy usually involves one of two methods:

One catches the sun's rays on reflectors and concentrates them in a smaller area, much as a magnifying glass does. This more intense heat is then used to produce steam from water, which in turn operates a turbine to produce electric power. (A power plant using this method of converting sunshine to electricity was put into operation in Egypt in 1913.)

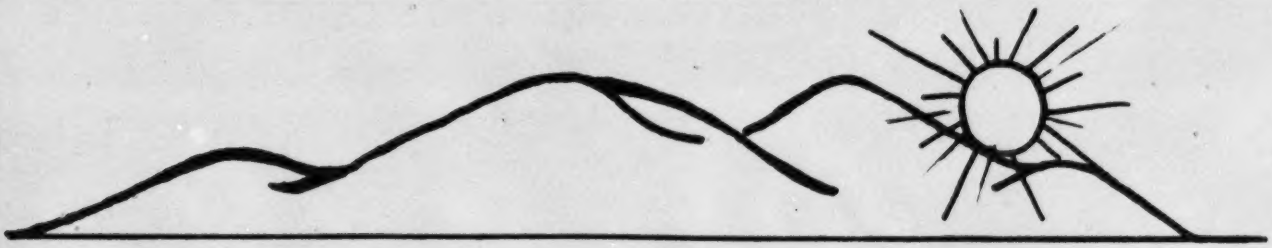
The second method requires the sun's rays to pass through a photovoltaic cell, made of a substance such as silicon, that converts sunshine directly into electricity. Solar cells were first used to produce electricity in 1954 by an American research corporation.

Dependence on solar energy has several drawbacks, including nighttime and winter. Storage of solar energy -- in batteries, for example -- is very expensive. Virtually all solar energy systems now in operation require supplementary conventional systems.

Besides the weather and the seasons, geography affects the practicality of solar energy. It works best in the parts of the country with the most exposure to the sun -- in the South and the West. In such areas, solar energy may be far more valuable for air-conditioning than as a source of heat.

The cost of direct conversion of sunshine to electricity through solar cells is high. Also, considerable heat is produced during the generation of electricity from solar energy.

Of the various uses of solar energy, heating and cooling appear to be the ones with most immediate practical value. What does our future hold?



FACT SHEET: GEOTHERMAL

"Old Faithful" in Yellowstone National Park has been a popular tourist attraction for many years. It erupts about every 60 minutes, shooting steam as much as 200 feet into the air. This most famous of all geysers is also a visual sign of one source of energy -- geothermal energy.

Geothermal energy is basically the heat deep inside the earth. Far beneath the surface is molten rock. In some places (particularly the western states) some of the molten rock has worked itself up close to the earth's crust. If the rock comes in contact with the underground water, and the water then rises to the earth's surface, it can result in hot springs or geysers, like "Old Faithful."

Locating geothermal energy sources is similar to the search for oil and natural gas. Many of the prospecting techniques developed by the oil industry can be used in finding and producing at least some of the geothermal resources. The challenge is to convert geothermal energy into a more useable form. One oil company has already found a way to harness the earth's internal heat to produce electricity at The Geysers, in northern California.

The dry steam produced at The Geysers fields, and the wet steam found in Yellowstone National Park and in many western states, are just two forms of geothermal energy. Dry steam geothermal fields are rare. Currently, most attention is focused on locating and developing technology for wet steam deposits.

A third type of geothermal energy is called "geopressured water." It exists widely beneath the Gulf Coast states of Louisiana and Texas, both onshore and offshore. These geopressured deposits have been trapped beneath the earth by insulating clay beds. If harnessed, geopressured waters could provide not only heat energy but also hydraulic (mechanical) energy and some natural gas as well.

A fourth type is called "hot dry rock" formations ("dry" because these rocks have not come into contact with underground waters). Indications are that these deep, hot rock deposits may be the most abundant geothermal resource in this country. The fifth type of geothermal energy is called "magma" -- molten (very hot liquid or partly liquid) rock. Magma is generally located deep within the earth.

Before even a modest fraction of geothermal energy becomes available to generate electricity, heat homes, and provide power for energy-intensive industries, some environmental, technical and economic problems must be overcome: what to do with salt water, toxic liquid wastes, hydrogen sulfide and methane that may come to the surface when geothermal fluids are produced; how to keep equipment from melting under the very high temperatures deep within the earth, and how to keep drill pipe from being eaten through and wearing out quickly when it comes in contact with the hard rock and very salty water; and how to bring down the costs of drilling in geothermal zones (where the costs now are about 50 percent higher than in drilling a typical onshore oil or gas well at comparable depths).

How practical is geothermal energy? What will our future hold?

FACT SHEET: MOVING WATER

Man has used moving water to turn paddle wheels and mill wheels for many years. Dams have been built where no natural water fall existed. The power of the water falling through either a man-made dam system or over a natural waterfall can be converted to electricity.

Today, researchers are investigating new ways of converting the power of moving water into useful forms of energy. All these new ways are expensive to develop and construct. But, the energy source, moving water, is self-renewing and environmentally safe.

Only one potential ocean energy source has been used to date on a commercial scale: tidal power. Two major tidal power projects are in operation today, one in the Rance River in France, where it flows into the English Channel; the other off the Ura River, where its waters meet the arctic waters of the Barents Sea near Murmansk, U.S.S.R. Both generate electricity as the tides move in and out. The Rance tidal works is capable of meeting the electrical power needs of a city with 250,000 people.

We have no tidal power plants in the United States, although experiments were conducted and plans made to harness the tides entering and leaving the Bay of Fundy near Passamaquoddy, Maine. The tides there rise to 40 or more feet. The project, started in the 1930's, was abandoned before construction began because of its high cost and the ready availability of other energy sources.

As our oil and natural gas resources have diminished, and environmental concerns have delayed or prevented a number of coal mining and nuclear power projects, interest in tidal power has been revived. What does our future hold?

FACT SHEET: WIND

Winds have been feared by people through the ages and around the globe because of their destructive power. But, wind is a practical energy source. In fact, wind is one of our oldest energy sources. At least 5000 years ago, the Egyptians used sails on Nile River boats. The Persians, in 200 B.C., used wind turbines to grind their grain.

In the past 100 years, millions of small windmills have been used in the United States to pump water and generate electricity. You can still see some in operation on farms and ranches throughout the middle and western states.

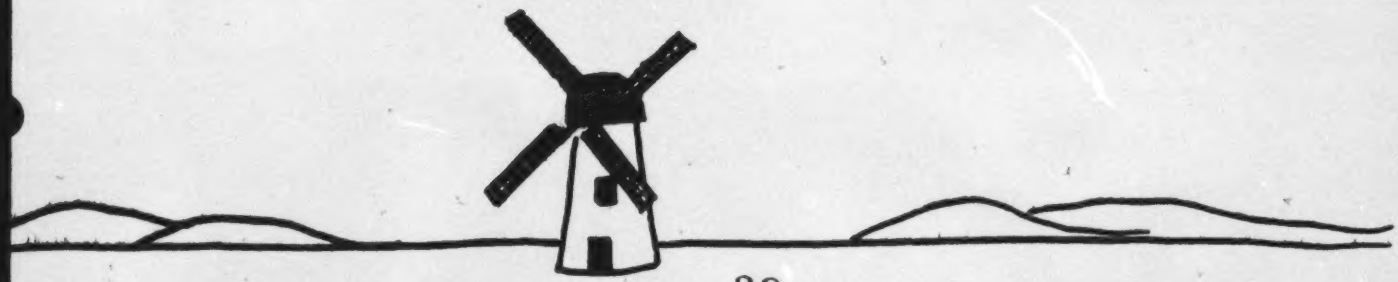
A number of larger windmills have been built -- mostly in Europe -- for experimental generation of electricity. The world's largest, however, was the Smith-Putnam machine built near Rutland, Vermont, in 1941. For more than three years, this 175-foot-diameter, propeller-type machine produced electricity. But, in that era of cheap oil and natural gas, wind power was not attractive enough to be further developed.

Today, though, with our higher energy costs and declining reserves of oil and natural gas, there is renewed interest in wind power. Researchers are experimenting with many types of wind machines. Some are like farm windmills. Some look like multibladed bicycle wheels. Others contain propellers or paddles. Still others are vertical-axis turbine or airfoil machines that look like eggbeaters. Another type is the cupped anemometer you have probably seen measuring wind speed. The mechanical energy of these machines can be used directly to pump fluids or do other work, or it can be converted to electricity, heat or fuel.

The concept of wind power is inherently simple, it's inexhaustible, and it's nonpolluting.

But, wind power also has problems. Being an indirect form of solar energy, wind has some of the same disadvantages. The average wind strength varies from one area to another. In all areas, it's not steady. And the equipment to harness it is expensive. Wind machines already in commercial production cost about four times as much as ordinary electric generators.

In order to supply just 20% of our energy needs we would need hundreds of thousands of huge windmills all over the United States. The most promising use of wind power will most likely be on a small scale. What will our future hold?



ACTIVITY 3. Energy Resources "New" and Old -- Where Do They Come From?

Objectives: In this activity, students locate major energy resources on a United States map and identify geographic areas that are relatively "poor" or "rich" in energy resources.

Organizing Ideas:

1. Energy resources are not evenly distributed throughout the nation.
2. Transporting energy resources to where they are needed can be costly, economically and environmentally.

Resources:

Geography textbooks and atlases might be used to supplement the map set that is provided.

Student Materials:

Colored pencils, pens, or crayons (for the map exercises)

Handouts (provided in the Student Materials Packet)

U. S. Outline Map (SM 3.1)

Energy Resources "New" and Old -- Where Do They Come From? (SM 3.2)

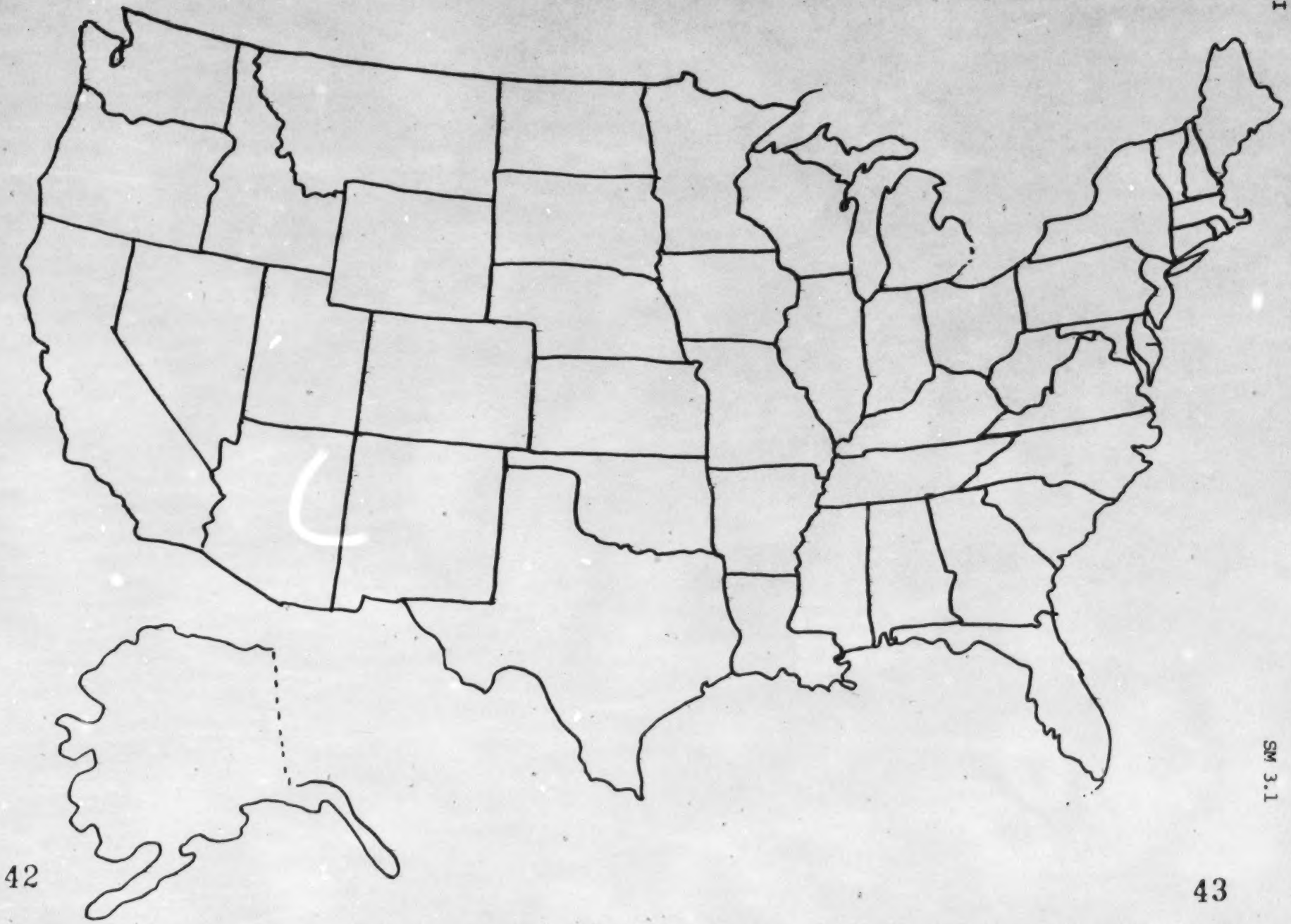
Map Set:
- Coal Fields of the United States (SM 3.3)
- Oil and Gas Fields in the United States (SM 3.3)
- Central Station Nuclear Power Plants (SM 3.4)
- Uranium Resources Western United States (SM 3.4)
- Solar Energy Availability (SM 3.5)
- Location of Geothermal Resources in the United States (SM 3.5)
- Annual Average of Available Wind Power (SM 3.6)

Suggested Procedures:

1. Using the United States outline map (SM 3.1) and the map sets (and other available materials), ask students to divide the nation into regions,

perhaps outlining their own region, and then to create their own map symbols and key to show whether each region has a small, moderate, or ample supply of each energy resource (coal, oil (and natural gas), nuclear, solar, geothermal, wind). Students might work individually or in small groups. (Suggested regional divisions are Northeast, Mid Atlantic, South, Midwest, Northwest, West, and Southwest.)

2. When students have completed their maps, distribute handout SM 3.2, and ask students to use their maps to complete the chart, summarizing the distribution of energy resources in the United States.
3. In a follow-up discussion, ask students to consider questions such as:
   a. What energy generation problems face regions such as the Northeast (particularly the New England states of Maine, New Hampshire, and Vermont) or the Midwest (particularly Wisconsin and Minnesota)?
   b. On the basis of the available evidence, which source of energy for electricity and heat seems best for your state? (Pennsylvania, or students might be assigned to represent different states)
   (Follow-up questions might ask students to consider relative transportation and pollution costs as well as local needs, e.g., location of ports, problems associated with pipelines.)
   c. If for some reason, citizens' groups or government agencies opposed your first choice, what would be your second choice for energy generation in your state?
4. This activity might be extended to encompass the distribution of energy resources worldwide in order to emphasize the global nature of the issues and worldwide interdependence.



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SM 3.1

42

43

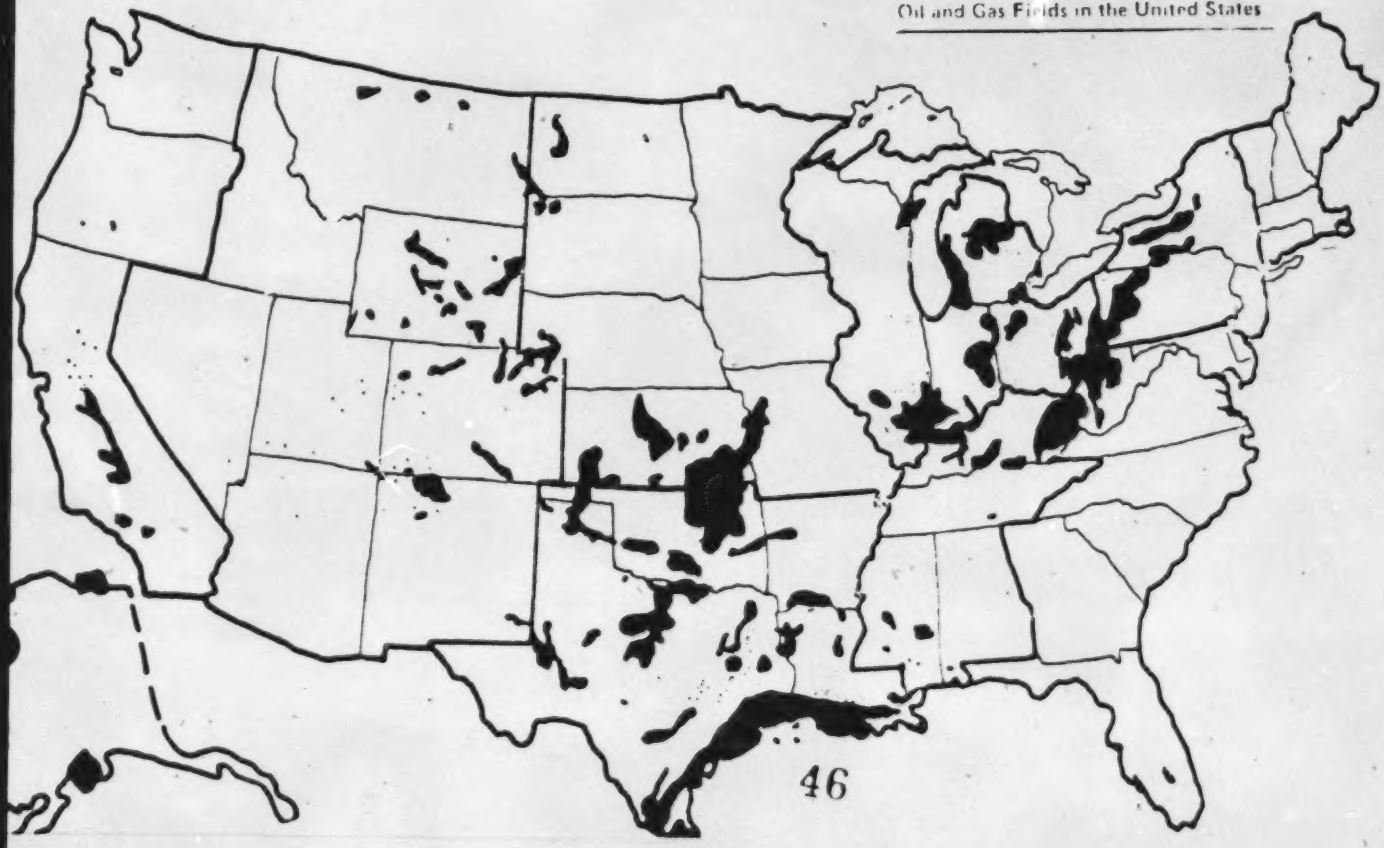
SM 3.2

Energy Resources "New" and Old -- Where Do They Come From?

Energy Resource	Energy Rich Areas	Energy Poor Areas
Fossil Fuels		
Solar Energy		
Geothermal Sources		
Nuclear Power Plants		

COAL FIELDS OF THE UNITED STATES
(FROM UNITED STATES GEOLOGICAL SURVEY)

Oil and Gas Fields in the United States



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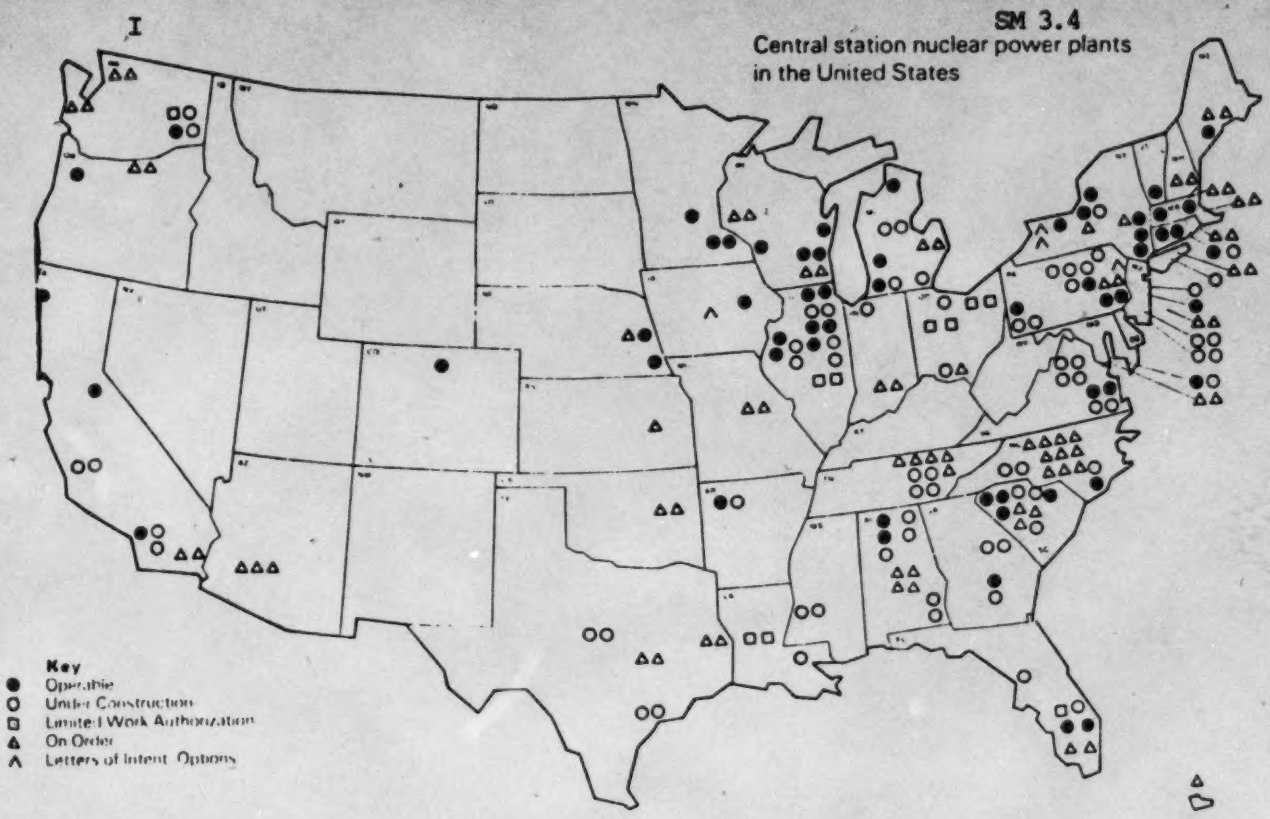
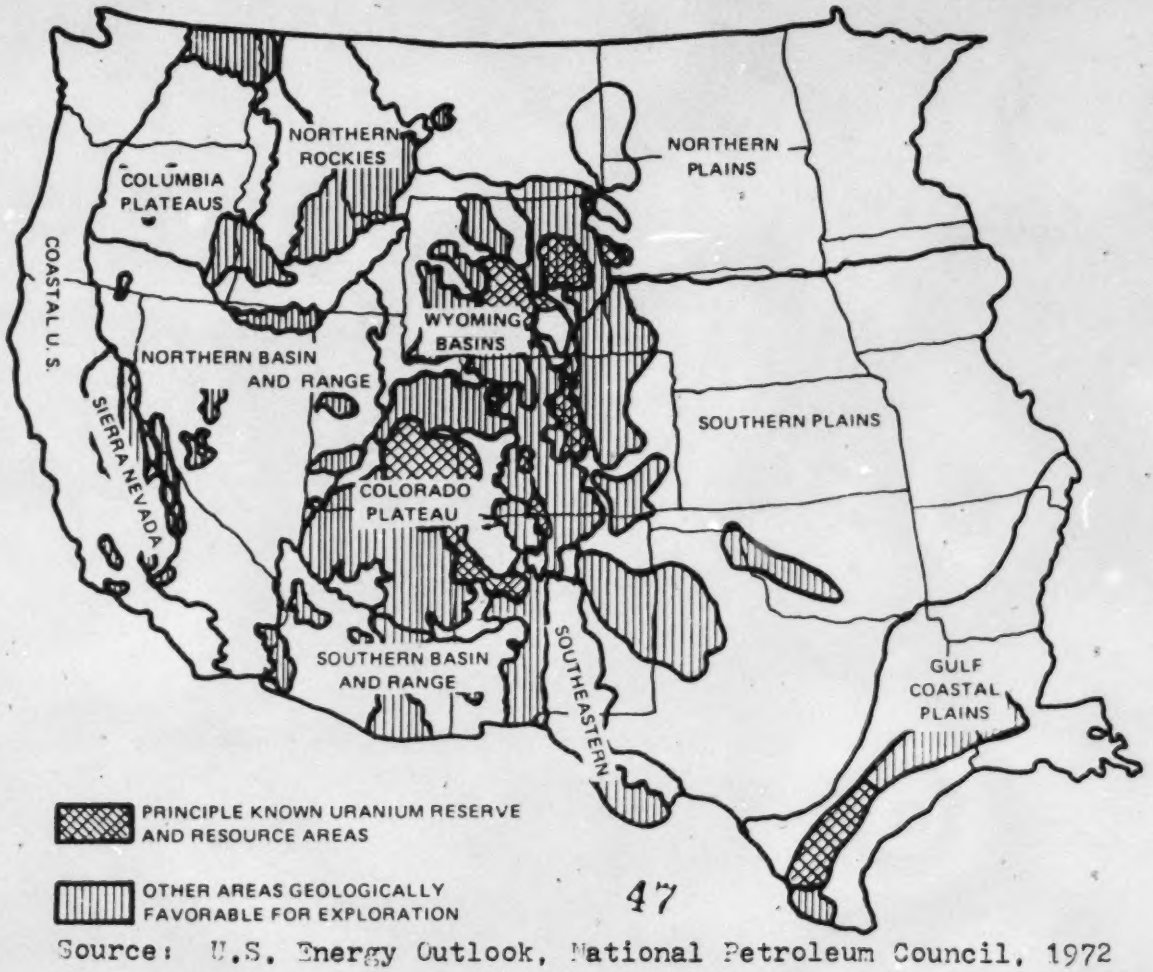
SM 3.4

Central station nuclear power plants in the United States



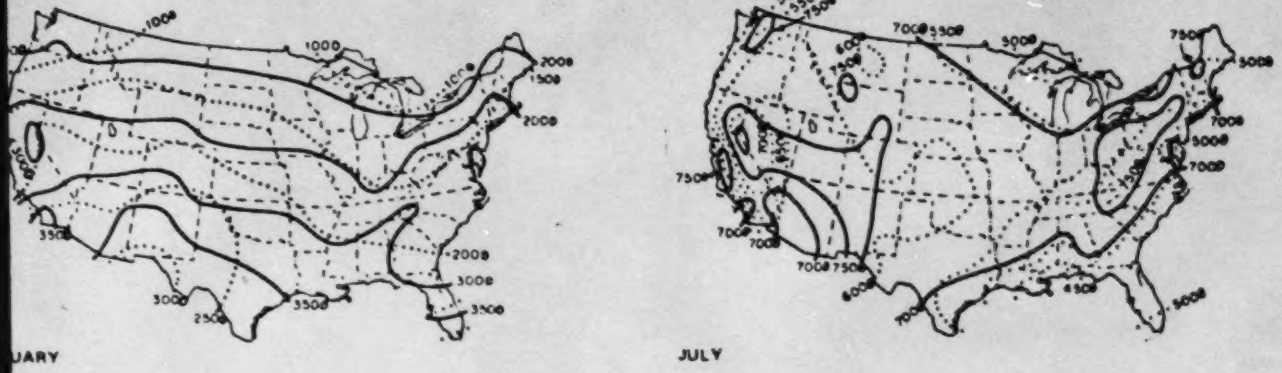
Uranium Resources in the Western United States



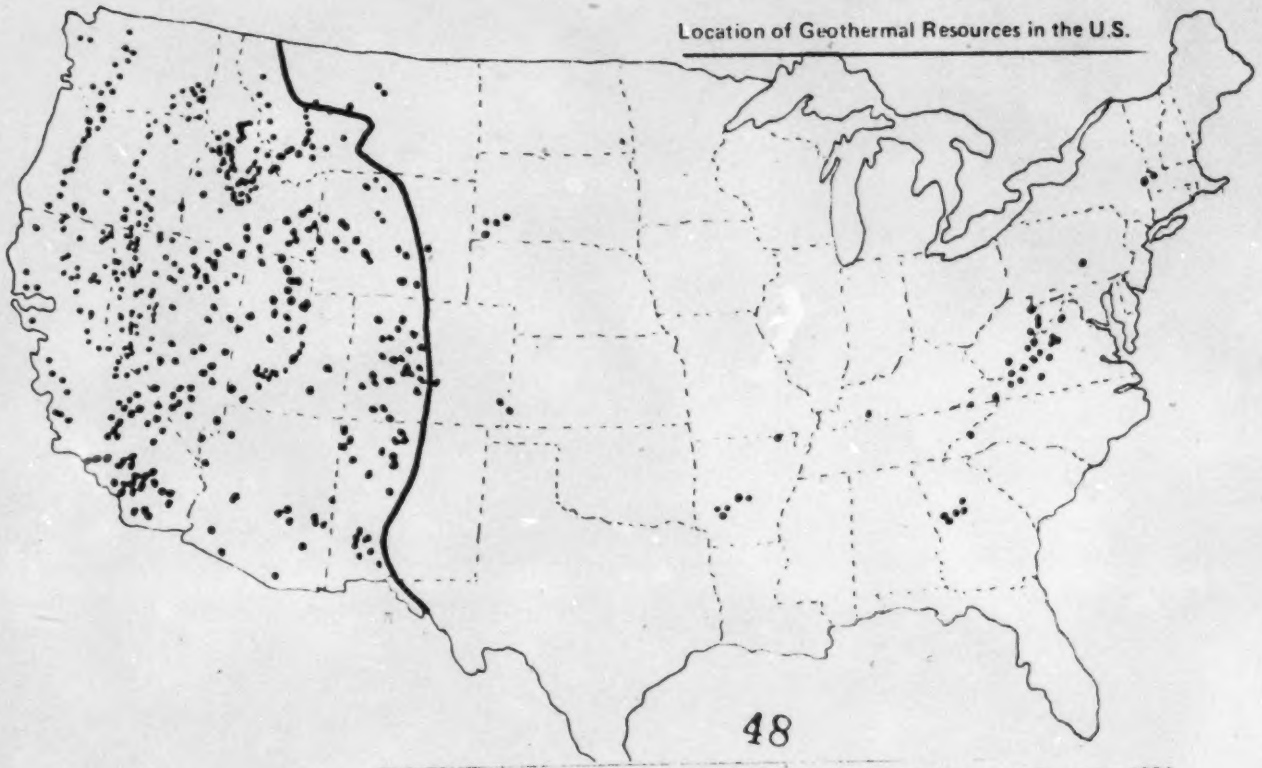
Source: U.S. Energy Outlook, National Petroleum Council, 1972

Solar Energy Availability

The amount of solar energy available at any given time varies greatly. Some idea of the geographical and seasonal variation is given by the two illustrations below.

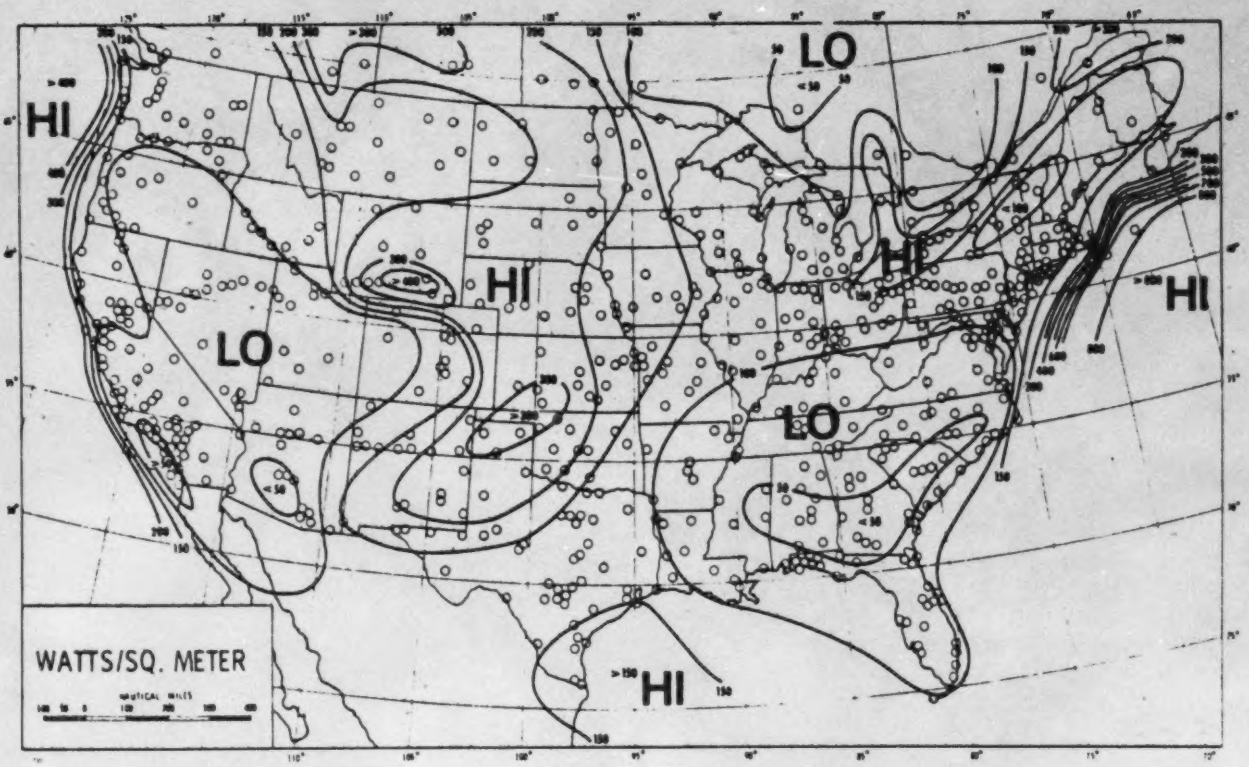


Lines of equal total daily solar energy at the ground on cloudless days (solid lines) and on days of average cloudiness (dotted lines) in January and July.



Data from "Project Independence Report," Federal Energy Administration, November 1974.

• Areas of Promise



Annual average of available wind power.

ACTIVITY 4. Energy and My Future -- Where Do I Stand?

Objectives: After sharing and reviewing their findings about energy generation options (from worksheets, maps, and other reference materials), students complete a decision-making map. (To complete the map, students identify the issue and the goal, select what appear to be the three most promising (energy) options, identify the likely consequences of each, and make a tentative decision based on the available evidence.)

Organizing Ideas: Sound decisions require consideration of alternative responses in terms of the available evidence and one's values.

1. Each energy generation source has advantages and disadvantages.
2. There is no one best future source of energy; when supply, technological, economic, environmental, and other factors are considered, no one energy source is ideal.

Student Materials:

Handouts (provided in the Student Materials Packet)

Energy and My Future -- Where Do I Stand? (SM 4.1, 4.2)

Decision-Making Map

Transparency (provided in the Student Materials Packet)

Decision-Making Map (same as handout)

Suggested Procedures:

1. Since the overall purpose of this module is to encourage and assist students to make reasoned decisions about a crucial urban environment-quality of life issue, it will likely be desirable to review the students' findings from previous activities, to explain the decision-making map

and process, and to communicate the importance of informed citizens making rational choices. (It's our future that's at stake.)

The decision-making map transparency might be used alone or in conjunction with the handouts to explain the process.

2. The handout, "Energy and My Future -- Where Do I Stand," SM 4.1-4.2, is intended to assist students in identifying the environmental issue(s) and their quality of life goal(s), in preparation for decision-making. Then, students might complete the decision-making map individually or as a class. In the former case, students might present, compare, and defend their decisions -- and have the opportunity to challenge others and change their minds.

   To narrow the scope of the issue, students might focus on future energy generation sources for their own region (e.g., Pennsylvania).

Energy and My Future -- Where Do I Stand?

Before taking a position or deciding "Where do I stand?", it is desirable to sort out the issues or problems. Listed below are three sample environmental issue statements. Read these, and then write your own issue statements in the spaces provided. Ask yourself, "What is the major energy generation problem?"

What's the Issue?

1. Which energy source will best meet future needs?
2. What new energy generation technology do we need to maintain our standard of living?
3. What will happen when our old energy sources run out?
4. _____
5. _____

What's Our Goal?

The next step in decision-making involves deciding what the goal or outcome should be. In this case, we are concerned with energy generation and the quality of our lives. How do you want the energy generation issue or problem you stated above to turn out? Write a sentence or two that describes your goal.

Goal Statement: _____

_____

_____

_____

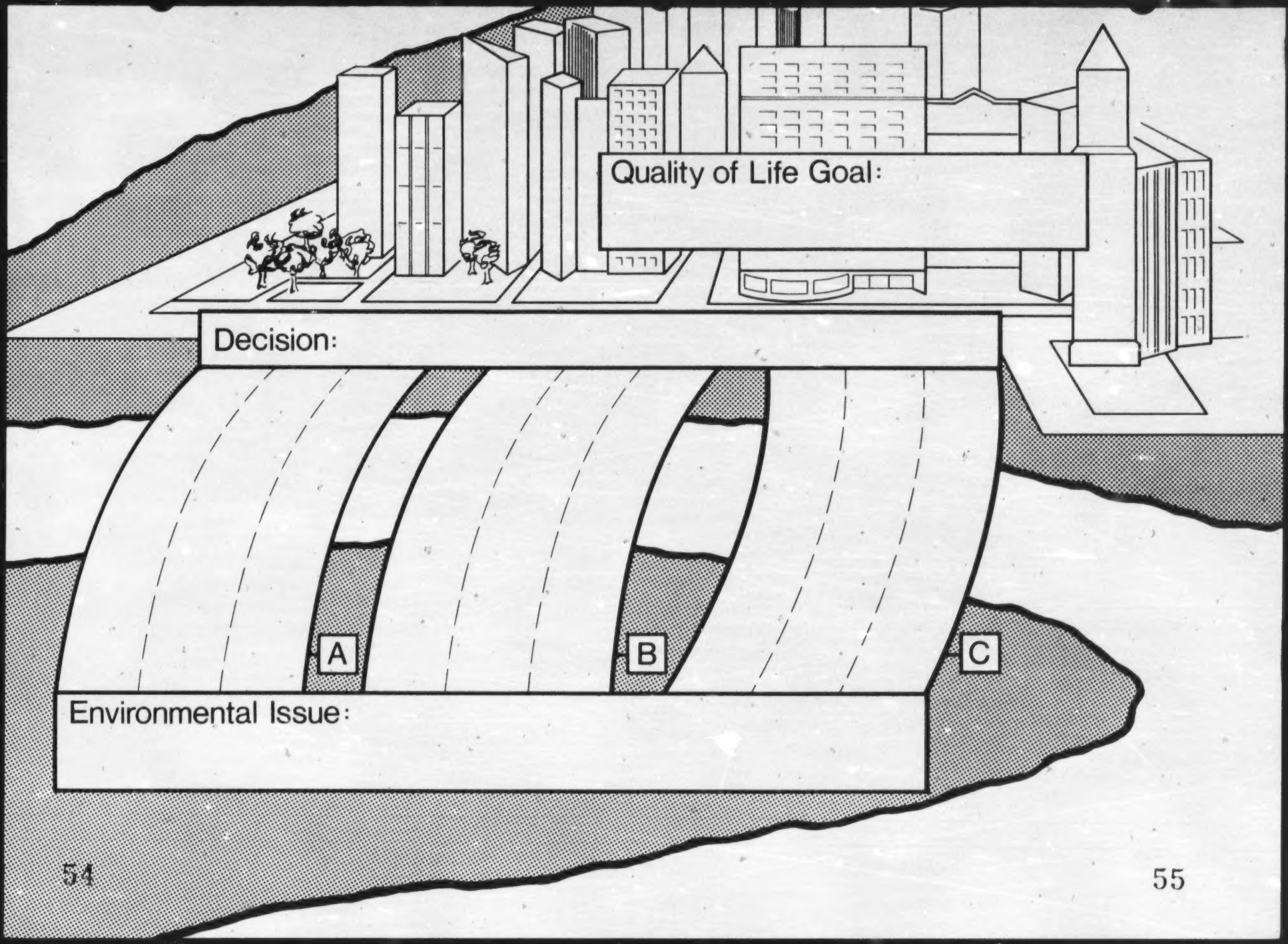
_____

Now What?

In the last few sections of this module, you have studied old and "new" ways of generating energy. Now is the time to decide which of these energy choices or options seems best. Which one (or combination) is most likely to resolve the issue or problem you have stated and lead toward the quality of life goal you have identified?

Review the activities you have just completed to help you decide. Remember -- for every option, there are both positive and negative side-effects. For example, nuclear energy may be plentiful and economical in the long run, but there is the risk of radiation. Or, while sunlight is free, large areas of land are needed for solar collectors to generate electricity.

Once you have reviewed the choices and the evidence, make a decision. Sometimes deciding is hard to do -- there is no one completely right answer. What choice seems best to you? Do it -- decide -- where do I stand?


Quality of Life Goal:
Decision:
A
B
C
Environmental Issue:

ACTIVITY 5. Energy Conference, 1984

Objectives: Students acknowledge and present other points of view about energy by participating in an energy conference simulation in which they role play representatives of diverse interest groups.

Organizing Ideas: People's decisions are influenced by their values.

1. Values are standards for determining what is good or desirable.
2. Values are learned from other people such as parents, friends, and teachers, and from direct experience.

Resources:

Suggested participants, their positions, and a hypothetical-real setting are described on the following pages. (Part or all of these materials might be duplicated for student use.)

Suggested Procedures:

1. Describe the situation, and assign students or ask them to select roles (two-three students might represent each group). Provide five-ten minutes for students to develop their positions (list priorities and arguments) before convening the Energy Conference. Meanwhile, brief DOE officials on their role in conducting the hearing. This introduction might take place the day before the conference is scheduled to provide more preparation time.
2. Allow each group three-four minutes to present their case to the DOE officials. Questions might be raised after each presentation or saved until each group has presented its case. Encourage DOE officials to ask the interest groups to justify their positions.

3. Provide DOE officials with time to reach and announce their decision(s) and the reasons for them. Meanwhile, each student might write a paragraph indicating what he/she expects the outcome to be and the reasons why. (Depending on time allotments, the DOE decision(s) and follow-up discussion might take place the following day.)
4. In a follow-up discussion, students might be asked to compare the DOE decision(s) with their own choices (from Activity 4) and to account for the differences. Additional questions for consideration include:
   a. What do our choices suggest about what we value?
   b. Why do you suppose that people's values differ?
   c. How do values influence personal and public (government) decision-making?
5. Variations: establish a world (rather than a national) setting for the Energy Conference to emphasize the global nature of energy questions and answers; create additional interest groups to reflect particular local concerns (e.g., Pacesetter, an environmental organization).

The Setting

The year is 1984. Because citizens and government leaders have delayed making difficult decisions, energy generation is now a critical problem. To head off complete disaster, an energy conference has been called by the U. S. Department of Energy (DOE). After reviewing the testimony of various interest groups at public hearings, DOE officials will make recommendations to the President for immediate action.

Representatives of each participating interest group will present their case to DOE officials. DOE officials can ask questions, and anyone can challenge the arguments that are presented by the various groups. After the testimony and question-answer period, DOE officials will announce their decision(s).

The Participants

DOE Officials (the Secretary of Energy and advisors)

Created in 1977, the DOE is charged with coordinating local, state, and national energy policies in order to encourage less use of oil and gas, enforce conservation measures, and support efforts to develop new energy generation sources.

Environmental Protection Agency (EPA) Officials

The EPA was created to set and enforce environmental standards for air and water quality. Their concerns include industrial air and water pollution, disposal of solid wastes and municipal sewage, and land reclamation following strip-mining.

City Officials

Representatives from the National League of Mayors are concerned about the quality of life in urban centers, particularly meeting their cities' energy needs and maintaining employment while providing a healthy environment.

Oil Company Officials

Oil company concerns include obtaining support for exploration for new oil sources, transportation availability and costs, and deregulation of prices.

Coal Company Officials

Coal companies want permission to mine new areas and funds for research (for example, research on coal gasification, converting coal into gas, which is less polluting).

United Mine Workers

Miners want stricter safety standards in the coal mines and more jobs.

Solar Power Advocates

This group wants funds for research on solar energy and opposes spending money for development of fossil fuels since they will soon run out.

Trash Power Advocates

This group wants land for dump sites and funds for the construction of new facilities and research to develop the technology to make biomass conversion more economical.

Nuclear Power Association

This group wants access to water supplies (needed to cool reactors) and money for new technology and waste disposal.

Back to Earth Movement

This group does not want to see any expansion of nuclear or electric power plants. They believe that we should live as earlier generations did, for example, with wood fires for heat and light.

Energy Generation: Sources and Consequences

MODULE EVALUATION

Please complete immediately after module use and return to C. Combleth, 4A01 Forbes Quadrangle, University of Pittsburgh, Pittsburgh, PA 15260

Teacher _____ School _____

Address _____

Grade/Subject Area _____ Date _____

A. Module Use Checklist

Please indicate whether you and/or your students used each section of this module by circling either YES or NO.

YES NO 1. Overview

YES NO 2. Teacher Background Information

YES NO 3. Activity Preview

YES NO 4. Pretest

(Activity 1. Energy -- What Is It?)

YES NO 5. What is Energy? What Difference Does It Make? (Parts A-C)

YES NO 6. Energy Loss Demonstration

YES NO 7. Optional Pendulum Experiment

YES NO 8. What Forms of Energy Are There? (Parts E-G)

(Activity 2. Energy Generation -- What Are The Options?)

YES NO 9. Consumption Graph (Part A)

YES NO 10. Energy Resource Research (Part B)

YES NO 11. Fact Sheets

(Activity 3. Energy Resources New and Old -- Where Do They Come From?)

YES NO 12. Mapwork

YES NO 13. Chart

A. Module Use Checklist - continued

YES NO 14. Activity 4. Energy and My Future -- Where Do I Stand?

YES NO 15. Activity 5. Energy Conference 1984

B. Initial Reactions

Please comment briefly on each of the following aspects of the module.

1. Importance of (knowledge, skills, and attitudinal) objectives:

2. Significance of content:

3. Appropriateness of activities (procedures, materials):

4. Useability, ease of teaching, practicality:

5. Student reactions:

6. Your overall reaction to the module (check one):

___ Very Positive; ___ Positive; ___ Neutral or Uncertain;

___ Negative; ___ Very Negative

Thank you.